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A nonlinear switching mechanism in quantum dot and metallic nanoparticle hybrid systems

Mahi R Singh
University of Western Ontario, Canada

Abstract

In nano-optics there has been considerable interest in studying the strong light-matter interactions which occur due to the enhanced local electromagnetic fields produced by metallic nanoparticles (MNPs). Strong surface Plasmon polariton local fields are particularly important for nonlinear optical processes including surface-enhanced Raman scattering and second harmonic (SH) generation. The nonlinear phenomena scale with a high power of the local field. The symmetry of a MNP and the polarization of the applied field have also played very important roles in local field enhancement. In a number of studies, semiconductor quantum dots (QDs) have been combined with MNPs to investigate the strong light-matter interactions due to the enhanced local field of the MNP plasmons. QDs are ideal to study the light matter interaction due their size-tunable optical properties. A variety of optical processes in QD-MNP hybrid systems are enhanced by the interaction of excitons in the QD with localized surface plasmons in the MNP. The optical processes which have been studied are photo-catalysis, light-harvesting and photovoltaics, SP-enhanced fluorescence, and Förster resonance energy transfer.We have theoretically and experimentally investigated second harmonic generation and two photon photoluminescence in CdS quantum dots near metallic nanoparticles. We have performed experimental investigations on the intensity of the SH field produced by CdS QDs in the presence of MNPs. The experiment was performed in transmission with spectrally-resolved photon counting detection (1P28 Hamamatsu photomultiplier and Stanford Research SR400 Gated Photon Counter). The pulsed laser used to generate the SH signal was a tunable mode-locked Ti:Sapphire (KMLabs) set at a wavelength of 790 nm, with 50 fs pulse width and 80 MHz repetition rate. A residual continuous-wave (CW) laser light coming from the 532 nm doubled Ng:YAG pumping laser also reaches the sample. It is found that the enhancement of the second harmonic signal can be switched on and off by changing the Ng:YAG pumping laser field intensity. Alternatively, the second harmonic signal enhancement can be turned on or off by changing the frequency of the Ng:YAG pumping laser. These are interesting findings which can be used to fabricate nonlinear all optical nano-switching devices from hybrid systems.

Biography

Mahi R. Singh received PhD (1976) degrees from Banaras Hindu University, Varanasi in condensed matter physics. After that he was awarded an Alenxander von Humbold Fellow in Stuttgart University, Germany from 1979 to 1981. Currently he is professor in this university. He was a visiting professor at University of Houston, He also worked as a chief researcher at CRL HITACHI, Tokyo and he was a visiting professor and Royal Society Professor at University of Oxford, UK. He was the director of the Centre of Chemical Physics and theoretical physics program at Western. Dr. Singh has worked in many research are of science and technology including nanoscience, nanotechnology, nanophotonics, optoelectronics, semiconductor here structures, high temperature superconductors, nanophotonics, plasmonics, polarotonics and nanoscience and technology.